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Author's address

D. Lavoie *(delavoie@nrcan.gc.ca)*
GSC Quebec
Quebec Geoscience Centre
880, chemin Sainte-Foy
C.P. 7500
Sainte-Foy, (Québec)
G1V 4C7

Stratigraphic framework for the Cambrian Chaudière Nappe in the external domain of the Humber Zone in the Quebec Re-entrant, and preliminary correlation with adjacent stratigraphic frameworks[1]

Denis Lavoie
GSC Quebec, Quebec

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Abstract: The Chaudière Nappe is limited to the north by the Logan's Line and associated mélange units, and to the south by the Foulon Fault. Sedimentary units of the Chaudière Nappe form the Sillery Group which consists of the Sainte-Foy, Saint-Nicolas, and Breakeyville formations. The biostratigraphic information suggests that the Saint-Nicolas Formation is Early Cambrian. The Sainte-Foy Formation tectonically underlies the Saint-Nicolas Formation, the former consists predominantly of variously coloured mudstone. The Saint-Nicolas Formation is divided into three units: a lower massive and coarse-grained sandstone, a middle cyclic turbidite, and an upper red mudstone. The Breakeyville Formation consists of two units, a lower conglomerate-sandstone and an upper mudstone-sandstone.

Correlation with adjacent stratigraphic frameworks is based on the recognition of the massive lower unit of the Saint-Nicolas Formation in other successions, and on correlation of the lower conglomerate of the Breakeyville Formation with Upper Cambrian conglomerate in eastern Quebec.

Résumé : La nappe de la Chaudière est limitée, au nord, par la ligne de Logan et les unités de mélange associées et, au sud, par la faille du Foulon. Les unités sédimentaires de la nappe de la Chaudière forment le Groupe de Sillery qui se compose des formations de Sainte-Foy, de Saint-Nicolas et de Breakeyville. La biostratigraphie indique que la Formation de Saint-Nicolas est du Cambrien précoce. La Formation de Sainte-Foy est tectoniquement sous-jacente à la Formation de Saint-Nicolas et se compose principalement de mudstones de couleurs variées. La Formation de Saint-Nicolas est divisée en trois unités : un grès grossier et massif à la base, des turbidites cycliques dans la partie médiane et un mudstone rouge au sommet. La Formation de Breakeyville consiste en deux unités, un conglomérat-grès à la base et un mudstone-grès au sommet.

La corrélation avec les schémas stratigraphiques adjacents est basée sur la reconnaissance de l'unité massive de grès de la Formation de Saint-Nicolas dans les autres successions et sur la corrélation du conglomérat inférieur de la Formation de Breakeyville avec les conglomérats du Cambrien supérieur dans l'est du Québec.

[1] Appalachian Forelands and St. Lawrence Platform NATMAP

INTRODUCTION

Cambrian–Lower Ordovician continental slope sediments of the Humber Zone outcrop for some 1000 km along the St. Lawrence River in eastern Quebec (Fig. 1). These sediments record the evolution of the rift-drift, passive margin, and foreland basin in the Quebec Re-entrant. Laurentia slope sediments are preserved in a number of stacked tectonostratigraphic nappes recording various segments (proximal and/or distal) of the Lower Paleozoic continental margin. The current stratigraphic framework for the Humber Zone is complex because of nappe-restricted units. Biostratigraphic analysis coupled with lithostratigraphic studies are in progress as part of the Appalachian Foreland and St. Lawrence Platform NATMAP project. These studies are critical for correlation of the stratigraphy across nappe boundaries in the Quebec Re-entrant and with successions of the St. Lawrence Promontory in western Newfoundland.

The continental slope succession is recorded by the Cambrian–Ordovician Curling and Cow Head groups in western Newfoundland (James and Stevens, 1986; Waldron and Palmer, 2000; Palmer et al., 2001; Burden et al., 2001) (Fig. 1). The integration of the regional paleogeographic picture (James et al., 1989) with tectonic studies (Waldron and Stockmal, 1994; Stockmal et al., 1995) was instrumental in the discovery of oil reservoirs in western Newfoundland (Cooper et al., 2001).

This paper describes the stratigraphic framework for the Chaudière Nappe in the external domain of the Humber Zone near Québec (Fig. 1, 2). The most recent studies of that nappe was that of St-Julien in the mid-1970s (published in 1995) and of Ogunyomi (1980). Recent field work in this structural element as well as in other nappes in the external domain allow to initiate the correlation of the local stratigraphic nomenclature.

GEOLOGICAL AND STRATIGRAPHIC SETTING

Continental slope deposits of the Humber Zone in the Quebec Re-entrant are part of the Quebec Supergroup outcropping from the international boundary to Gaspésie (Fig. 1). These poorly fossiliferous and locally little exposed sedimentary rocks are preserved in southeasterly dipping thrust slices in the external tectonic domain as defined by St. Julien and Hubert (1975).

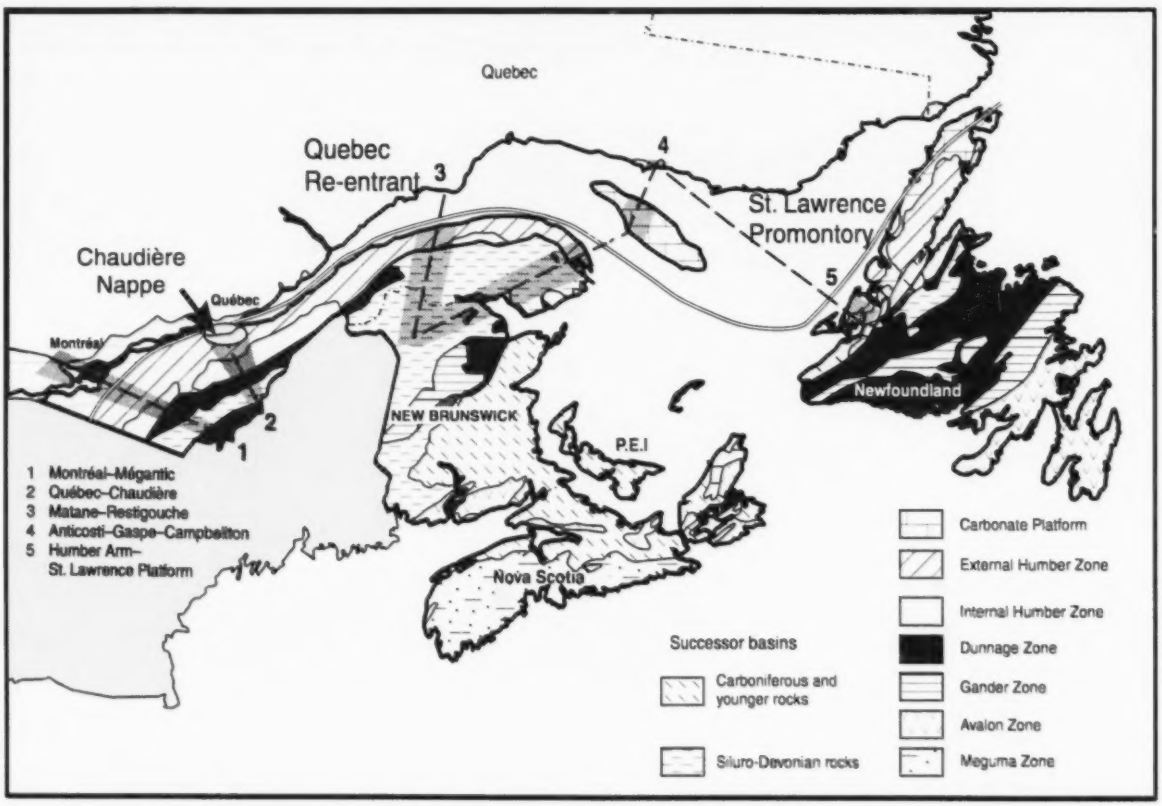

Figure 1. *Simplified geological map for eastern Canada with the location of the five tectonostratigraphic transects of the NATMAP project. The Chaudière Nappe belongs to the Cambrian–Ordovician Humber Zone and occurs at the northern end of transect #2.*

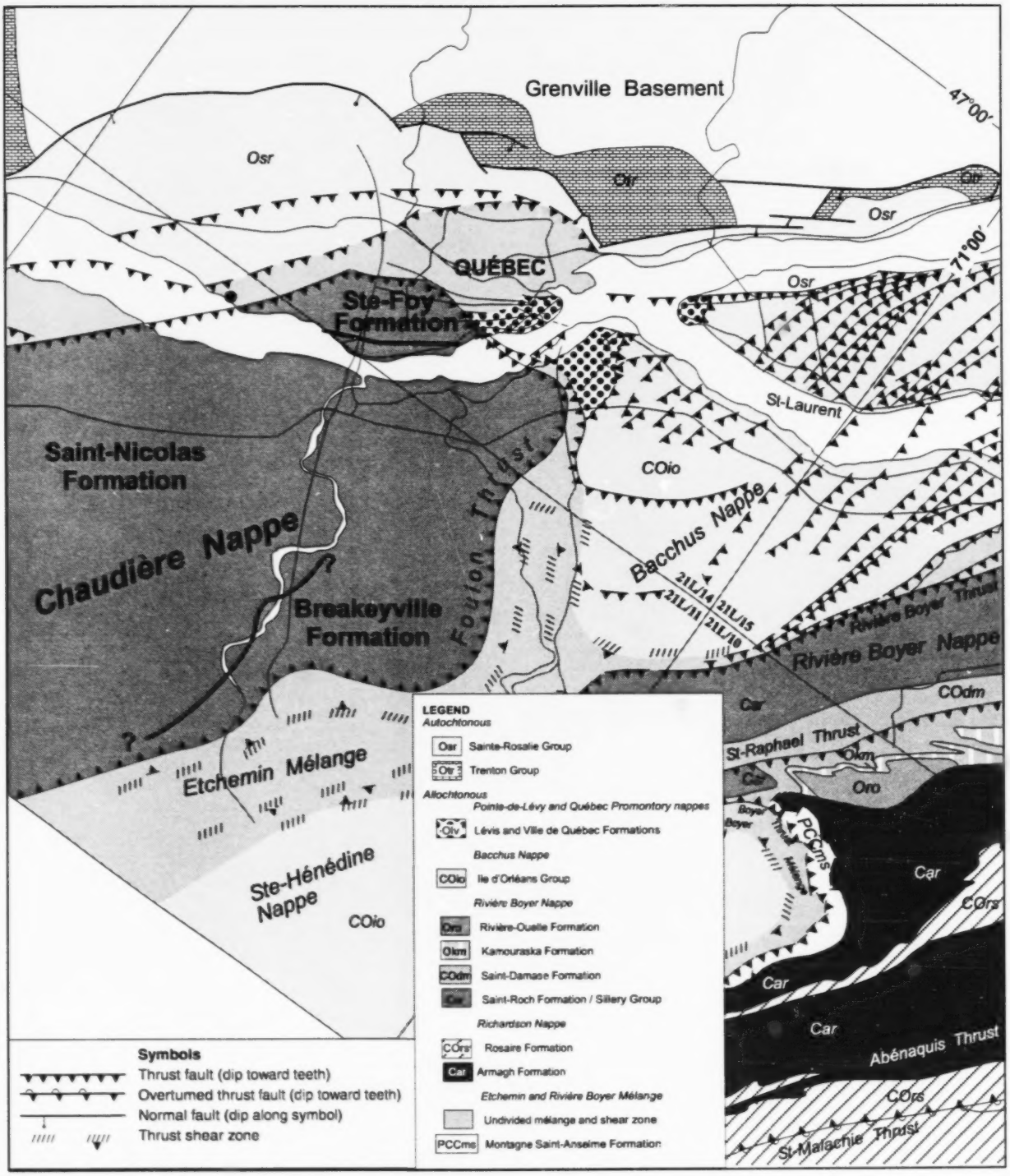

Figure 2. *Simplified geological map of the Québec area with the location of the Chaudière Nappe. Preliminary geographical distribution of the three formations within the nappe limit is shown. Figure* modified from *Lebel and Kirkwood (1998).*

The lack of a coherent stratigraphic framework for the Humber Zone in eastern Quebec and in particular for rift-drift and passive margin stage sediments, largely lies in its structural complexity, but also because of limited biostratigraphic data and of a predominantly mudstone-rich sedimentary assemblage. The succession was divided in broad stratigraphic packages consisting of fine-grained sediments separated by or interbedded with coarse-grained units (Lavoie, 1997, 1998). The lowest rock package (unit RP1) consists of (?)uppermost Precambrian–Lower Cambrian siliciclastic rocks capped by a regionally extensive coarse-grained sandstone unit and corresponds to the rift-early drift succession. The initiation of passive margin sedimentation is recorded in the overlying package (unit RP2) consisting of upper Lower Cambrian to uppermost Middle Cambrian fine-grained siliciclastic rocks. A third package (unit RP3) consists of Upper Cambrian–lowermost Ordovician mixed siliciclastic and limestone conglomerate, sandstone, and shale. Finally, a last package (unit RP4) consists of Lower–Middle Ordovician fine-grained successions of siliciclastic rocks and limestone units locally punctuated by conglomerate and marks the end of the passive margin sedimentation in the Quebec Re-entrant.

The limited biostratigraphic database for the Chaudière Nappe indicates that the succession consists of deposits correlatable with units RP1 and RP2, although presence of unit RP3 sediments is likely; palynological studies are in progress.

CAMBRIAN SEDIMENTS OF THE CHAUDIÈRE NAPPE

The Chaudière Nappe is one of the ten tectonostratigraphic nappes or units recognized by St-Julien (1995) in the Québec area. To the north, this nappe is limited from the parautochtonous domain by Logan's Line and associated mélange units, and to the south by the Foulon Fault (Fig. 2). Within this nappe, the sedimentary succession forms the Sillery Group (Slivitzky and St-Julien, 1987). The Sillery Group (Fig. 3) consists of three formations, from base to top, the Sainte-Foy, the Saint-Nicolas, and the Breakeyville formations (Slivitzky and St-Julien, 1987; St-Julien, 1995).

Sainte-Foy Formation

This unit is found in the northern sector of the Chaudière Nappe (Fig. 2). The Sainte-Foy Formation consists of multicoloured mudstone with subordinate siltstone and sandstone. St-Julien (1995) identified four lithofacies (units SF2 to SF5) in this formation. The sediments are intensely deformed near the Chaudière Nappe limit to the north and the formation is in faulted contact with the Saint-Nicolas Formation (Fig. 4a). The red mudstone lithofacies dominates the succession, occurring in decimetre- to metre-thick intervals (Fig. 4b). The green mudstone lithofacies is commonly associated with a significant percentage of silt. The Sainte-Foy Formation is devoid of macrofauna. From its assumed position below the

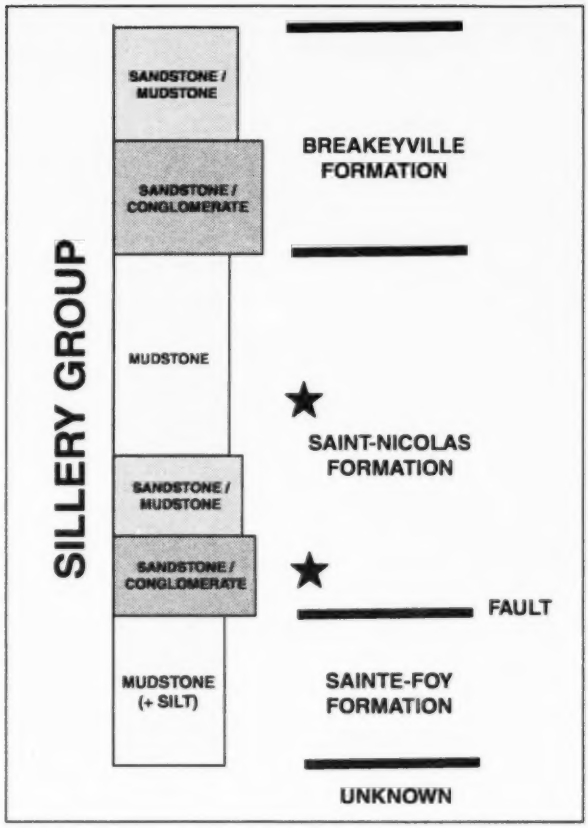

Figure 3. *General stratigraphy of the Sillery Group. The groups consists of three formations in which fining-upward trends are clearly present for the uppermost two units. Not to scale. The filled stars indicate units for which biostratigraphic control is available from macrofauna.*

Saint-Nicolas Formation, which is carrying mid- to late Early Cambrian faunal elements (*see below*), the formation is interpreted to be no younger than Early Cambrian.

Saint-Nicolas Formation

As defined by St-Julien (1995), the Saint-Nicolas Formation consists of six lithofacies (units SN2 to SN7) interpreted as recurring at various intervals in the stratigraphy of the formation. The author is dividing the formation into three units (Fig. 3), a lower, thickly bedded succession of greenish sandstone-conglomerate with subordinate mudstone; a middle cyclic turbiditic sandstone-mudstone; and an upper, predominantly red mudstone interval. The middle and upper units are tectonically repeated (from folding and thrust faulting) many times along the Chaudière River. As a whole, the Saint-Nicolas Formation is a fining-upward unit which reflects a progressive deepening of the depositional setting from the late rift-drift to the passive margin stages. The author is now using the contact between the upper red mudstone unit and a limestone conglomerate-orthoquartzite unit as

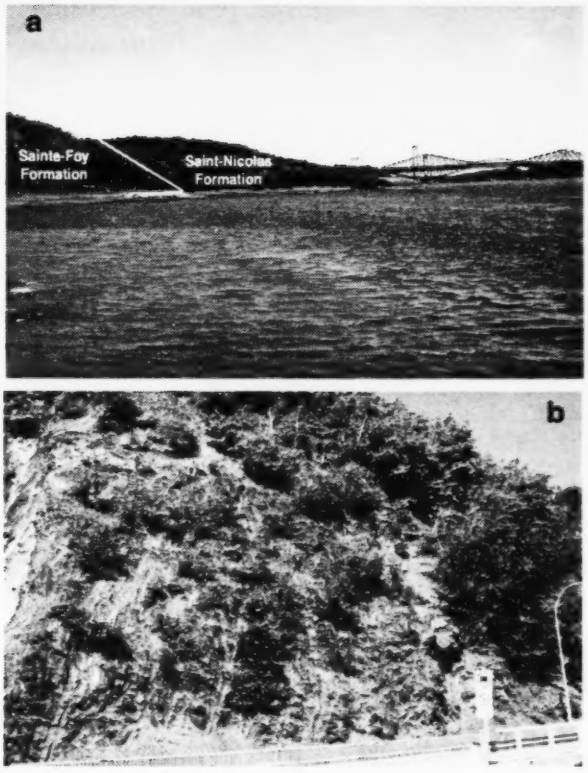

***Figure 4. a)** Fault contact between the fine-grained succession of the Sainte-Foy Formation and the thick beds of pebbly sandstone at the base of the Saint-Nicolas Formation. **b)** Road cut exposure (Chemin du Foulon in Sillery) showing the dominant red mudstone succession of the Sainte-Foy Formation with thin interbeds of siltstone.*

the contact with the overlying Breakeyville Formation. This has been done in order to ease the lithostratigraphic definition of the Breakeyville Formation and for correlation purposes with the eastern Quebec Cambrian succession.

The lower unit is characterized by thickly bedded green sandstone and conglomerate. This unit was designated as the "Charny Sandstones" by Rasetti (1946); this term has been rejected by St-Julien (1995). These sandstone units are in beds ranging from 20 cm up to 4 m in thickness (Fig. 5a), they are massive with few sedimentary structures besides some faint grading and vertical water-escape structures. The sandstone beds are not organized in any large-scale cyclic pattern, although the uppermost beds of this succession are showing evidence of storm remobilization of bottom sediments (Fig. 5b). The sandstone units are quite immature; angular sand- to granule-sized feldspar grains and mafic rock fragments are almost as abundant as quartz particles. These sandstone units are locally carrying the brachiopod *Botsfordia pretiosa* (Fig. 5c), a characteristic Early Cambrian element (Ulrich and Cooper, 1938). Moreover, these brachiopod-rich beds are locally interbedded with green and red mudstone, the latter characterized by the presence of the trace fossil *Oldhamia curvata*, another key late Early Cambrian ichnofauna (Lindholm and Casey, 1990).

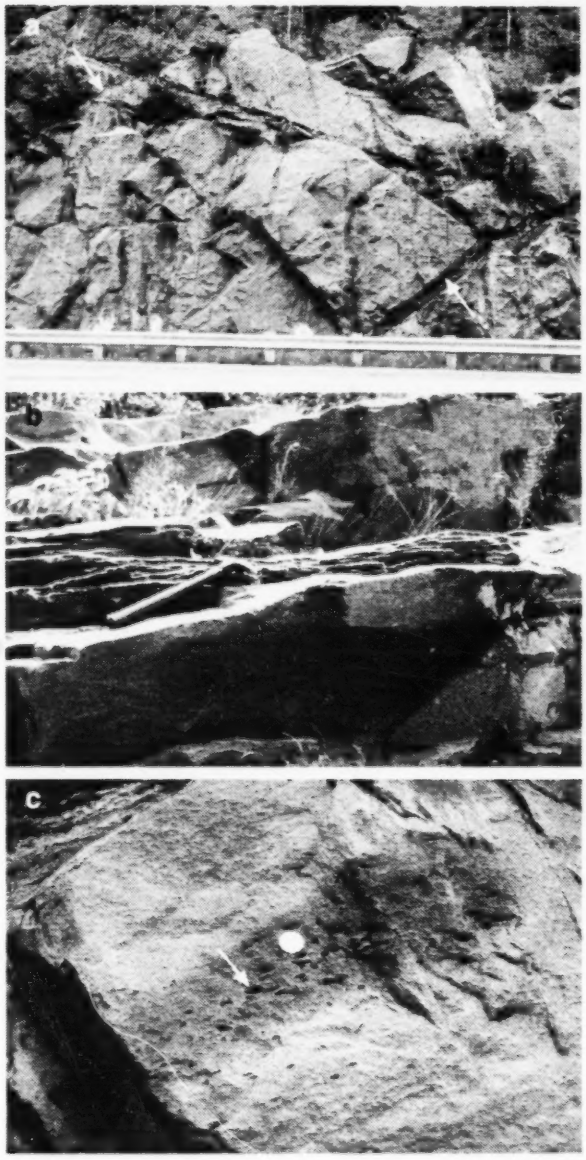

***Figure 5. a)** A 4 m thick pebbly green sandstone bed (between arrows) in the lower unit of the Saint-Nicolas Formation.* Oldhamia curvata *has been recovered from interbedded red mudstone. "La Grande Coupe" in Charny. **b)** Hummocky cross-stratification in siliceous sandstone at the top of the lower unit of the Saint-Nicolas Formation, Chaudière River. **c)** Abundant shells of* Botsfordia pretiosa *in sandstone of the lower unit of the Saint-Nicolas Formation. One dollar coin for scale. "La Grande Coupe" in Charny.*

The middle unit is in normal faulted contact with the lower sandstone assemblage. This unit consists of interbedded sandstone and mudstone. The sandstone occurs in beds ranging from 10 cm up to close to 1 m in thickness and is locally quartz-rich although most beds would be best described as arkose, some of these are dolomitic. The sandstone units are typified by sedimentary structures indicative of turbidity current deposition. The mudstone units occur in 10 cm up to 2 m intervals and they are most commonly green and grey. The sandstone-mudstone unit is arranged in metre-scale thinning- and fining-upward cycles (Fig. 6a). Locally, some limestone conglomerate units are present (Fig. 6b). These are characterized by abundant micrite fragments with *Salterella* indicative of an Early Cambrian source.

The upper unit conformably overlies the middle one, the transition is rapid and abrupt as the green mudstone-turbiditic sandstone assemblage rapidly gives way to a thick and predominantly red mudstone succession with some greenish siltstone-sandstone interbeds (Fig. 6c). This upper unit makes most of the Saint-Nicolas Formation although its exact thickness is unknown. This predominantly fine-grained succession is

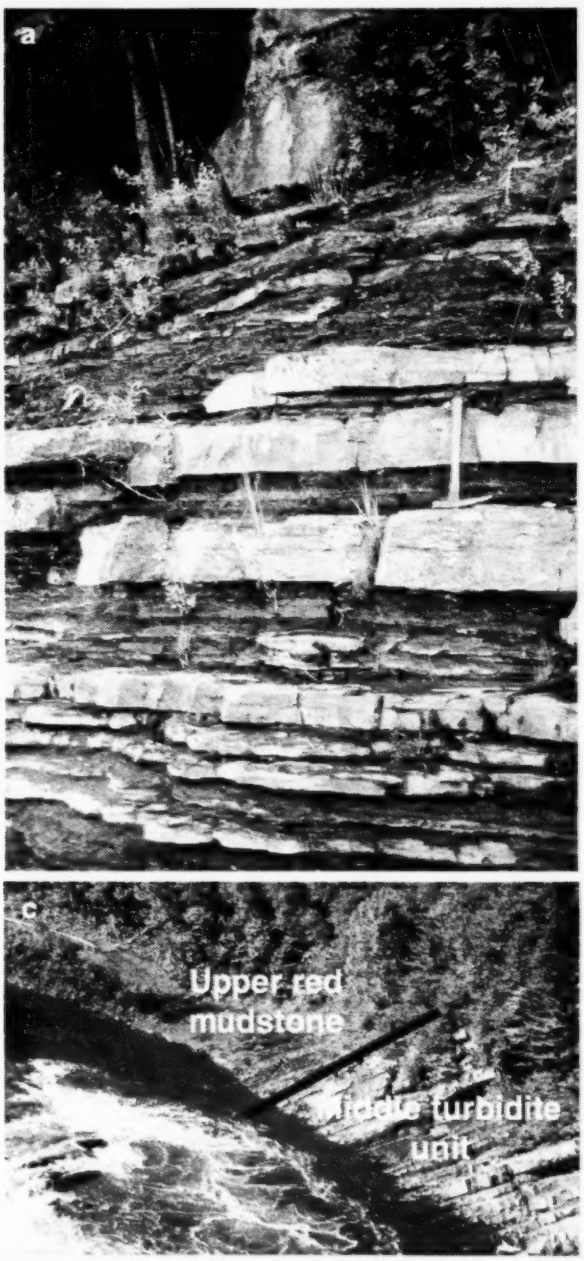

Figure 6. *a) Rhythmic sandstone-mudstone succession. Chaudière River. b) Monogenic limestone conglomerate with micrite fragments and quartz in the Saint-Nicolas Formation. Some micrite clasts are carrying* Saltarella. *Road cut south of Saint-Agapit. c) Abrupt stratigraphic contact, along the Chaudière River, between the cyclic middle turbidite unit and the overlying red mudstone-dominated unit of the Saint-Nicolas Formation.*

characterized by thin sandstone beds showing sedimentary structures indicative of distal turbidite. The exact age of that unit is unknown although locally, Early Cambrian brachiopods (*Botsfordia pretiosa*, St-Julien (1995)) have been recovered in a black shale unit.

Breakeyville Formation

This unit is the upper formation of the Sillery Group and occurs in the southern sector of the Chaudière Nappe (Fig. 2). St-Julien (1995) recognized five lithofacies (units SB2 to SB6) in the Breakeyville Formation. The Breakeyville Formation is here divided into two units, a lower coarse-grained interval and an upper mudstone-sandstone unit.

The lower interval is relatively thin; the best exposed section along the Chaudière River is 30 m thick. The oldest sediments consist of decimetre-thick and metre-wide lenses and beds of limestone conglomerate filling channels cutting into the red mudstone lithofacies of the Saint-Nicolas Formation. These conglomerate units are clast supported and dominated by rounded, granule- to pebble-sized limestone fragments. These fragments, forming up to 80% of total clasts consist in decreasing order of abundance of micrite, bioclastic (trilobites) wackestone and packstone, oolitic grainstone, thrombolitic and stromatolitic boundstone, oncolitic packstone, and rare dolostone (Fig. 7a). The other clasts are made up of quartz, siliciclastic fragments, and black mafic volcanic rocks. This conglomerate interval is locally absent and the lowermost sediments of the Breakeyville Formation consist of thickly bedded (up to 3 m thick) quartz-rich sandstone (Fig. 7b). These sandstone beds are locally microconglomeratic, and would be best described as orthoquartzite. These sandstone units define two decametre thick, thinning- and fining-upward successions. Decimetre thick, dark grey mudstone interbeds are present in the upper part of each cycles. The facies is devoid of internal sedimentary structures besides some faint parallel laminations and grading; dish-and-pillar fluid escape structures are abundant. No macrofauna has been observed in the sediments. The nature of the conglomerate suggests a potential correlation with Upper Cambrian conglomerate in eastern Quebec (*see below*).

The upper sedimentary interval consists of interbedded grey mudstone and sandstone. The arkosic sandstone units are in beds ranging from 20 cm to 1 m in thickness. These sandstone beds are locally graded, with rare parallel and crosslaminations. This sedimentary assemblage represents the uppermost interval preserved in the Chaudière Nappe stratigraphy. The age of that upper Breakeyville unit is still elusive.

REGIONAL STRATIGRAPHIC CORRELATION

Following the late Precambrian break-up of Laurentia, the continental margin of Laurentia experienced a succession of tectonic events, from an early rift-drift episode (Early Cambrian) and the following establishment of a passive margin (Middle Cambrian to Early Ordovician), its evolution ended in sedimentation in a Taconian foreland basin (Middle to Late Ordovician). This section will discuss general considerations pertinent to the evolution of that margin in the Cambrian.

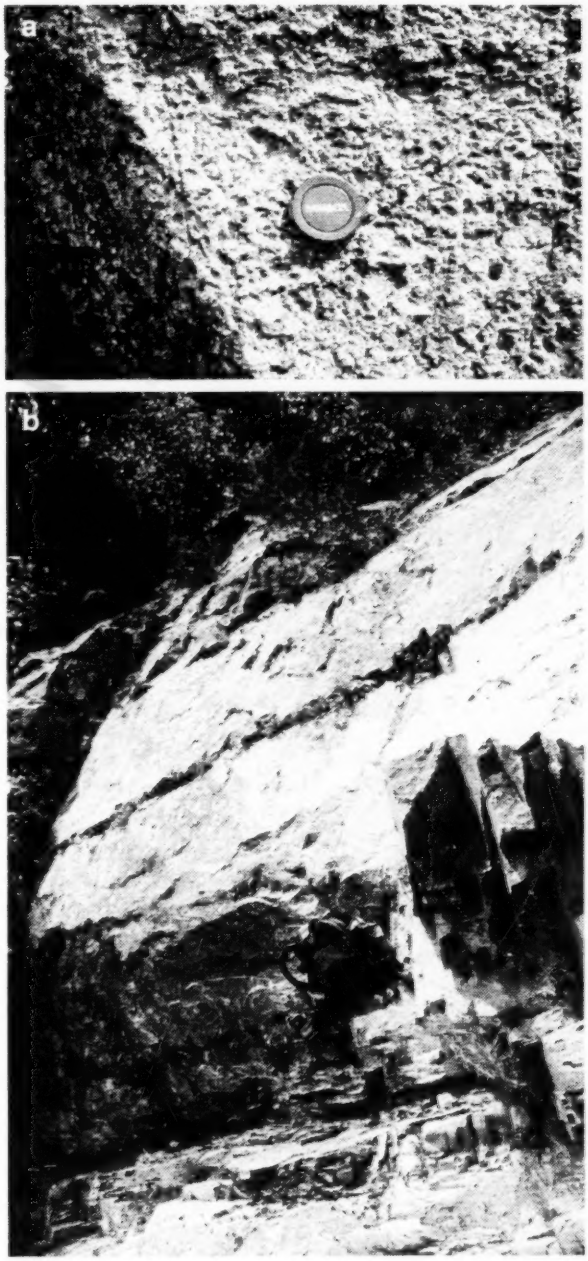

***Figure 7. a)** Polygenic limestone conglomerate at the base of the Breakeyville Formation, Chaudière River. Limestone fragments are highly diversified with respect to facies. **b)** Thick beds of orthoquartzite directly overlying the limestone conglomerate at the base of the Breakeyville Formation.*

Rift-drift episode

The shallow marine record of the rift-drift episode is meager in southern Quebec. In the autochthonous domain of the St. Lawrence Platform, the undated Potsdam Group unconformably overlies the Precambrian basement. In the internal domain of the Humber Zone, shallow-marine clastic and carbonate units of the Oak Hill Group (Charbonneau, 1980) are overlying rift volcanic rocks of the Tibbitt Hill Formation. In the Oak Hill Group, the Cheschire (quartzite) and Dunham (dolostone) formations have yielded Early Cambrian fauna (brachiopods, trilobites, *Salterella*; Clark (1936); Clark and McGerrigle (1944)). Outside the shallow-marine Oak Hill Group, Early Cambrian fauna are only known in the slope facies of the Humber Zone.

At the base of the slope succession, a thick succession of variegated mudstone with subordinate sandstone is overlying rift volcanic rocks. The sandstone beds are locally coarse-grained and in thickly bedded successions with abundant turbidity current and dewatering structures. In places, decimetre-thick beds of conglomerate with carbonate and phosphate fragments can be abundant (Lavoie, 1997). These units are the Sainte-Foy Formation in the Chaudière Nappe (St-Julien, 1995; this paper) and the basal beds of the Saint-Roch Group (formerly the Saint-Roch Formation of Hubert (1973)) in the Rivière Boyer and Rivière Sainte-Anne (eastern Quebec) nappes (Vallières, 1984; Lebel and Hubert, 1995; Lavoie, 1997). Recent work on these successions (Lavoie, 1997; this paper) allow the author to propose correlation of these units (Fig. 8) on the basis of similar sedimentary assemblage and stratigraphic position (below a distinctive sandstone unit, *see below*). These units are devoid of significant macrofauna, but the overlying massive sandstone unit is characterized by middle to upper Early Cambrian fauna (*see below*).

The lower mudstone-sandstone succession is overlain by a distinctive unit of massive and pebbly green sandstone with subordinate red and green mudstone. St-Julien (1995) included this unit at the base of the Saint-Nicolas Formation. In the Rivière Sainte-Anne Nappe, this distinctive unit is known informally as the "Unité des grès verts" (green sandstones unit) near the base of the Saint-Roch Group (Vallières, 1984). Thickness of that unit is rather fairly constant at roughly 600 m. The age of that unit is constrained by the presence of the inarticulate brachiopod *Botsfordia pretiosa* (St-Julien, 1995) and that of the trace fossil *Oldhamia curvata* (this paper) both diagnostic middle to upper Early Cambrian elements.

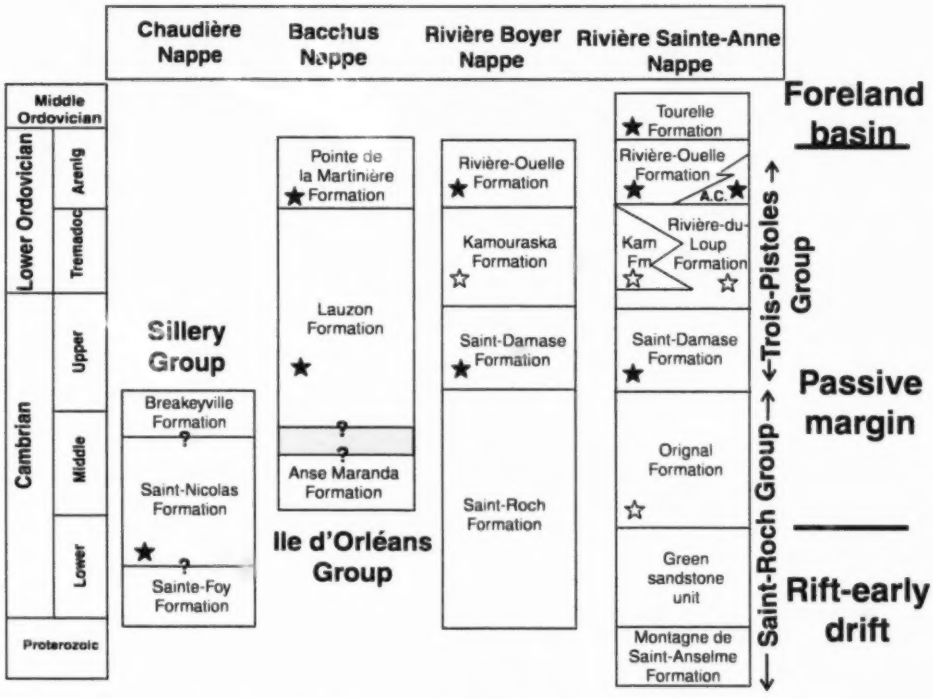

Figure 8. *Stratigraphic correlation chart for the rift-drift and passive margin successions for four of the tectonostratigraphic nappes in the Humber Zone of the Quebec Re-entrant. The stars indicate units for which biostratigraphic control is available from either macrofauna (filled stars) or microfauna (open stars). A.C. is for Anse-du-Crapaud member.*

The very distinctive massive sandstone unit is a useful correlation unit as it is recognized from Québec to western Newfoundland (Blow-Me-Down Brook and Irishtown formations, Palmer et al. (2001)).

The passive margin

The Early Cambrian rift-early drift episode ended in a major sea-level lowstand known as the "Hawke Bay event" in western Newfoundland (James et al., 1989). It is here proposed that the "Unité des grès verts" of the Saint-Roch Group and the massive sandstone-conglomerate unit at the base of the Saint-Nicolas Formation are the deep marine slope expression of that lowstand in Quebec. The shallow-marine lowstand clastic rocks were flooded by the transgressive sea level at the base of the Sauk II subsequence, which led to extensive passive margin carbonate sedimentation (James et al., 1989).

In the Quebec Re-entrant, the oldest (late Middle Cambrian) passive margin carbonate is the 30 m thick Corner-of-the-Beach Formation in eastern Quebec (Kindle, 1942; Lavoie, 2001). In southern Quebec, the shallow marine carbonate rocks of the Strites Pond Formation of the Philipsburg Group and Philipsburg slice (Salad Hersi and Lavoie, 2001) yielded Upper Cambrian (lower Skullrockian) conodont fauna (G. Nowlan, internal GSC paleontological report 008-GSN-2001, 2001). These last two formations are of restricted occurrence and the shallow marine record of the Sauk II and III subsequences (passive margin), but is mostly found in the Early Ordovician dolostone (Beekmantown and Phillipsburg groups and Romaine Formation) (Globensky, 1987; Desrochers, 1988; Salad Hersi and Lavoie, 2001).

In the Humber Zone, the first unit that followed deposition of the sandstone marking the end of the rift-early drift episode consists of a thin succession of slope carbonate rocks with arkosic to quartizitic sandstone and limestone conglomerate (Fig. 8). These sediments are found in the Saint-Nicolas Formation in the Chaudière Nappe (St-Julien, 1995; this paper), the Saint-Roch Formation in the Rivière Boyer Nappe (Hubert, 1973; Lebel and Hubert, 1995), and in the Orignal Formation in the Rivière Sainte-Anne Nappe (Lavoie, 1997). Palynological analysis of the Orignal Formation suggest an early Middle Cambrian age (Omnichron Associates, unpub. report, 2000). The limestone conglomerate (*see* description *in* Lavoie (1997)) is typified by abundant micrite fragments with *Epiphyton* and *Renalcis* calcimicrobes; moreover, some fragments with late Early Cambrian *Salterella* and archaeocyathans are present. The carbonate-rich lower interval is overlain by a thick succession of red, green, and minor black mudstone units with locally abundant siliceous, arkosic, and locally glauconitic sandstone that characterizes the above-listed formations. This succession is also developed at the base of Bacchus Nappe and forms the Anse-Maranda Formation (St-Julien, 1995; Lebel and Hubert, 1995; Longuépée and Cousineau, 2001).

Another major distinctive coarse-grained unit overlies the Middle Cambrian fine-grained interval (Fig. 8). This unit is known as the Lauzon Formation in the Bacchus Nappe (St-Julien, 1995; Longuépée and Cousineau, 2001), the Breakeyville Formation in the Chaudière Nappe (St-Julien, 1995; Lavoie, this paper), the Saint-Damase Formation in the Rivière Boyer and Rivière Sainte-Anne nappes (Hubert, 1973; Vallières, 1984; Lavoie, 1997, 1998), and the Cap Enragé and Grosses-Roches formations in the Rivière Sainte-Anne Nappe (Lajoie et al., 1974; Hendry, 1978; Lavoie, 1997, 1998). This unit consists of massive carbonate conglomerate with coarse-grained arkosic and less abundant siliceous sandstone and fine-grained mudstone. The thicker and coarser grained successions are found in the lower St. Lawrence Valley area; elsewhere (southern Quebec and Gaspésie), the succession is thinner and dominated by arkosic sandstone. Clasts in the conglomerate consist of various limestone indicative of a high-energy platform environment (Lavoie, 1997). Because of the lack of diagnostic metaozoans in the matrix, the youngest trilobites in limestone fragments have been used to indicate the minimum age of the conglomerate, which is early to mid-Upper Cambrian (Rasetti, 1946). These conglomerate units are also carrying a significant percentage of quartzite and arkosic sandstone fragments, basalt fragments, and uncommon, but very significant basement-derived gneiss and orthoquartzite (Lavoie, 1997, 1998); these last two types of fragments are restricted to the lower St. Lawrence Valley sections. This observation, coupled with the predominance of thicker and coarser grained succession in this area, suggest that the source area experienced major erosive events in the Late Cambrian.

The Upper Cambrian coarse-grained interval is overlain by a fine-grained succession of grey and black mudstone with subordinate siliceous turbiditic sandstone (Fig. 8). These occur in the upper part of the Lauzon Formation in the Bacchus Nappe (St-Julien, 1995), in the upper part of the Breakeyville Formation in the Chaudière Nappe (St-Julien, 1995; this paper), and in the Rivière-du-Loup Formation and in the upper member of the Grosses Roches Formation in the Rivière Boyer and Rivière Sainte-Anne nappes (Hendry, 1978; Vallières, 1984; Slivitzky et al., 1991; Lavoie, 1998). Palynological analysis of that unit suggest a latest Cambrian age from either acritarchs (Omnichron Associates, unpub. report, 2000) or the first presence of scolecodonts (Lavoie et al., 1998).

This fine-grained unit is interbedded with laterally highly discontinuous quartzite (Fig. 8). These quartzite beds with local limestone conglomerate intervals, are massive with few sedimentary structures although dewatering dish-and-pillar features can be abundant. These quartzite beds are known as the Kamouraska Formation (Hubert, 1973) and are present in the Rivière Boyer and Rivière Sainte-Anne nappes (Hubert, 1973; Vallières, 1984; Slivitzky et al., 1991). The interbedded mudstone yielded an earliest Ordovician fauna of scolecodonts and chitinozoans (Lavoie et al., 1998). Where the quartzite is absent, the fine-grained succession goes with no interruption into the next unit. Vallières (1984) introduced the term 'Trois-Pistoles Group' where the three-fold (two coarse-grained intervals separated by a fine-grained interval) Upper Cambrian rock assemblage is recognized (Saint-Damase, Rivière-du-Loup, and Kamouraska formations).

glomerate (Fig. 8). The limestones can locally be abundant and elsewhere totally absent; this resulted in problems with the stratigraphic framework (Lavoie, 1998). This unit is known as the Pointe de la Martinière Formation in the Bacchus Nappe (St-Julien, 1995; Longuépée and Cousineau, 2001), the Lévis Formation in the Québec area (Richardson, 1870), the Rivière-Ouelle Formation in the Rivière Boyer and Rivière Sainte-Anne nappes (Hubert, 1973; Lebel and Hubert, 1995), and the Cap-des-Rosiers and Anse-du-Crapaud formations in the Rivière Sainte-Anne Nappe (Kindle, 1938; Bernstein et al., 1992). The Anse-du-Crapaud Formation was named by Bernstein et al. (1992) in order to account for the local abundance of Early Ordovician slope limestones; however, and as proposed by Cousineau (1998), the present author suggests using the term Anse-du-Crapaud as an informal member of the Rivière-Ouelle Formation for sections with high carbonate content. This interval is Early Ordovician, based on Arenig faunal elements found in these rocks (Riva, 1972; Hubert, 1973; Landing et al., 1986; Bernstein et al., 1992; Maletz, 1992; Lavoie et al., 1998). Locally, Llanvirn graptolites have been described in the uppermost beds of that succession (Bernstein et al., 1992; Maletz, 1992). This unit marks the end of the passive margin episode on the continental slope, the overlying succession consisting of the Taconian-derived flysch (Tourelle Formation).

The regional correlation of passive margin slope units in the Quebec Re-entrant relies on the new biostratigraphic information as well as on the understanding of the lateral facies variations of the interval overlying the massive conglomerate-sandstone unit of the early Late Cambrian (Lavoie, 1998). The dark grey to black mudstone-dominated succession is locally interbedded with the thick quartzite unit, which laterally passes into thin intervals of thinly bedded quartzite, and eventually pinches out (Fig. 8).

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